Decoding Earth's Spectra Through its Evolution

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We have developed a characterization of the geological evolution of the Earth's atmosphere and surface in order to model the observable spectra of an Earth-like planet through its geological history. These calculations are designed to guide the interpretation of an observed spectrum of such a planet by future instruments that will characterize exoplanets. Our models focus on spectral features that either imply habitability or are required for habitability. These features are generated by H2O, CO2, CH4, O2, O3, N2O, and vegetation-like surface albedos. We chose six geological epochs to characterize. These epochs exhibit a wide range in abundance for these molecules, ranging from a CO2 rich early atmosphere, to a CO2/CH4-rich atmosphere around 2 billion years ago to a present-day atmosphere. We analyzed the spectra to quantify the strength of each important spectral feature in both the visible and thermal infrared spectral regions, and the resolutions require to unambiguously observe the features for each epoch. We find a wide range of spectral resolutions required for observing the different features. For example, H2O and O3 can be observed with relatively low resolution, while O2 and N2O require higher resolution. We also find that the inclusion of clouds in our models significantly affects both the strengths and resolutions required to observe all spectral features.